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A situation assessment method for rock burst based on multi-agent information fusion ☆

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ABSTRACT

An assessment approach to assess the likelihood of rock burst in coal mines by integrating the Multi-Agent System with data fusion techniques is proposed in this paper. We discuss an optimal algorithm for multi-sensor data fusion to improve the accuracy and reliability of the source data. Some model-based situation quantization methods are described and a rock burst situation quantitative assessment model incorporating improved Dempster–Shafer theory is presented. The Auto-Regressive, Moving Average and Holt–Winters models are used to address indefinability and inaccuracy of the prediction. A case study demonstrates that the proposed situation assessment model is capable of producing relatively accurate forecasts, and thereby it can provide coal mine decision-makers with an overview of the development of rock bursts.

1. Introduction

Identifying potential rock burst is one of the most difficult problems in coal mine safety monitoring and warning has aroused wide concern in academia and industry. The production mechanisms are complex and this problem remains unsolved yet, despite considerable research and experiments producing quantities of theoretical results [1–5]. On the basis of these theoretical results, engineers and technicians have developed a series of practical warning systems using monitoring micro earthquakes, rock pressure, acoustic emission, electromagnetic radiation, roof abscission layers, etc. These monitoring systems are playing an increasingly important role in preventing rock burst disasters and ensuring safety coal mine production. However, each system concentrates on a single mechanism of rock burst. An integrated framework combining the data sources has not been successfully constructed due to the diversity of information sources. Furthermore, fundamental early warning methods and information processing techniques have not been fully developed and most systems take alarm thresholds set from experience. Therefore, existing systems have high false alarm rates and warning failures are quite common.

In this paper, a rock burst situation assessment method by integrating the Multi-Agent System (MAS) with data fusion incorporating the complexity and distribution features of each rock burst monitoring system are proposed. More specifically, firstly, the MAS framework for rock burst assessment is introduced. Then, an optimal algorithm for multi-sensor data fusion to improve the accuracy and reliability of sensor data is developed. A multi-source data fusion method is proposed based on

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improved Dempster–Shafer (D–S) theory. All monitor system outcomes are fitted into the interval [0, 1]. Then, by incorporate the Auto-Regressive and Moving Average (ARMA) and Holt–Winters models into one algorithm one can forecast the rock burst situation. Finally, the effectiveness and efficiency of our proposed method is illustrated with experimental data.

This paper is organized as follows. Section 2 introduces the MAS data fusion model on the basis of the rock burst situation assessment requirement. An optimal multi-sensor data fusion algorithm is discussed in Section 3. The multi-source information fusion method and its quantitative method based on improved D–S theory is presented in Section 4. Section 5 addresses the ARMA and Holt–Winters models-based algorithms to forecast the rock burst situation. Section 6 shows that our proposed rock burst situation assessment model provides a relatively accurate forecast for experimental. Some findings are discussed in Section 7.

2. Data fusion model based on multi-agent system

The multi-source method for alarm and forecasting rock burst is widely used. However, this is less than satisfactory, due to random fault warnings for a diversity of reasons, and the abruptness of the warning before the actual rock burst. A warning system based on a situation assessment theory is proposed. It is extensively used in the field of military, transportation, disaster assessment, and computer networking.

The main tasks of a Rock Burst Situation Assessment (RBSA) system are as follows:

(a) to fuse the multi-source data from monitoring micro earthquakes, rock pressure, acoustic emission, electromagnetic radiation and so forth;
(b) to provide information connection and complementation among each type of sensor;
(c) to recognize and acquire time and spatial security-related elements; and
(d) to assess the rock burst situation and forecast future trends.

The general structure of an RBSA system is shown in Fig. 1.

The RBSA system includes four functional parts:

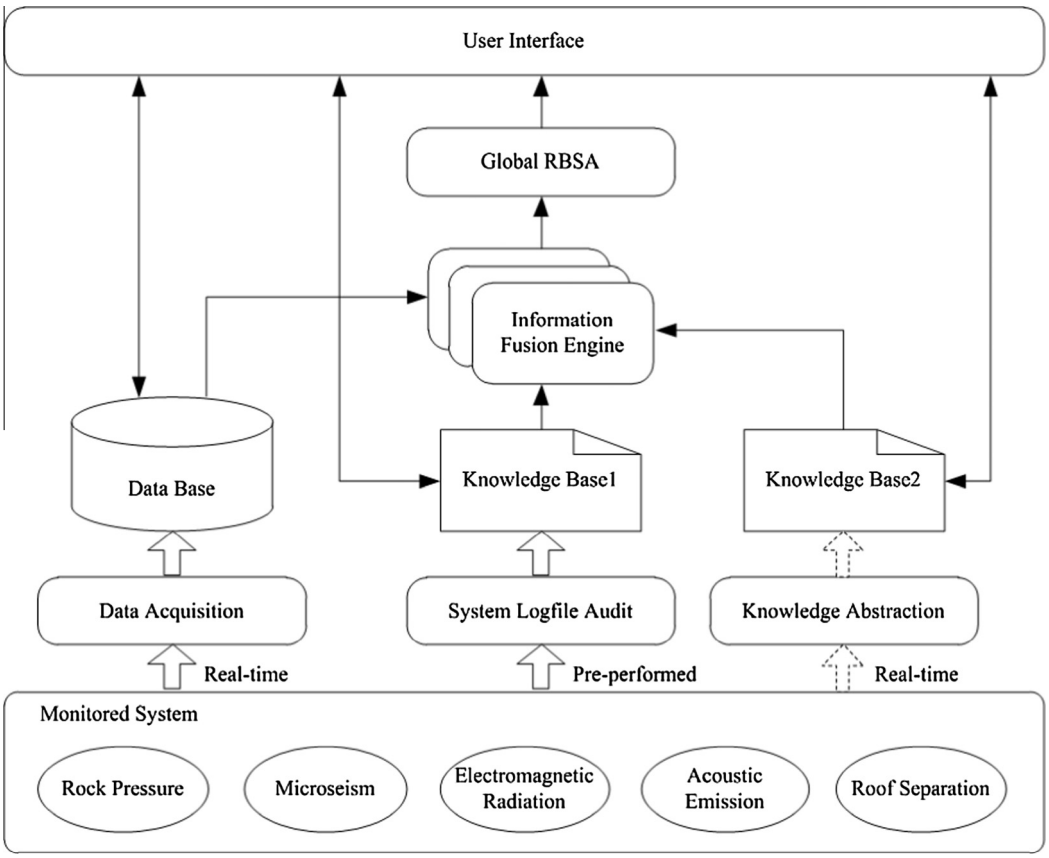

Fig. 1. General structure of the RBSA system.